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Reports
Troutwine
J.M.

Developing Graphical User Interfaces for MAGIS using ArcGIS

Final Report #: RMRS-01-JV-11222052-226

Final Report

For

"Developing Graphical User Interfaces for MAGIS using ArcGIS"

(RMRS-01-JV-11222052-226)

Prepared
by

Judy M. Troutwine
(406-542-3241)
and
Hans Zuuring
(406-243-6456)

Department of Forest Management
College of Forestry & Conservation
The University of Montana
Missoula, MT 59812

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USDA Forest Service
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INTRODUCTION

The initial statement of the RJVA agreement with the USDA Forest Service Forestry Sciences Lab – Missoula (FSL) refers to the mutual benefit and interest on enhancing the capability of and promoting the use of MAGIS (Multi-resource Analysis and Geographic Information System) for the purpose of constructing feasible and efficient fuel treatment plans for landscapes in view of other forest management objectives and constraints. The RJVA document states that "The purposes (sic) of this agreement is to develop, test, and debug a number of graphic user interfaces for MAGIS using the ArcGIS software. These interfaces are to become an integral part of MAGIS for performing data preparation and checking, specifying management alternatives, and display of results." Three interfaces, with attendant programmers' and users' documentation, were initially proposed:

a. Assembling and checking area data for building a MAGIS model.

b. Entering user specifications for building management alternatives.

c. Displaying MAGIS model results in various ways both spatially and temporally. Results shall also be easily processed by GIS software not included in this development effort.

Amendments Three and Four provided to some extent for effort in conjunction with IMI (Forest Service detached Washington Office group located in Ft. Collins, CO) to develop a combined software package. They also mentioned funding for two additional GIS interfaces: road options and associated costs, and assigning management options for treatment units polygons. Also, programming language code was to contain detailed documentation of the code itself.

Summary of previous progress

The **first progress report** (August 20, 2002) listed the benefits of combined effort between UM, FSL and IMI. Broad goals and envisioned software characteristics were listed as well as methods, initial results, and anticipated tasks of the collaboration. The implications far surpassed the original, stated purpose of the RJVA. UM participants suggested and provided technical support for high standards in the organization of the software package and in the design of the GIS interfaces. The lead UM programmer on the project functioned as a full member of the MAGIS development team, providing project management expertise by preparing agendas, leading MAGIS team meetings, and maintaining communications among collaborators (PI's, programmers, and, occasionally, FSL clients).

(1) Broad functional, structural, and design goals for the combined software package:

- Enhance/modify existing MAGIS capabilities with GIS functionality where appropriate. Interactive maps are to be included for both MAGIS and SNAP.

- Coordinate geospatial data import with that for IMI software.
- Interact with the SIMPPLLE simulator and the MPS and SNAP solvers.
- Provide a soundly organized, modular program structure.
- Provide GUIs to guide and simplify user-MAGIS interaction.

(2) Methods: evaluated a range of technical approaches to software design and programming options; chose two programming options as suitable; prepared overall MAGIS framework description documents, potential program structure documents, and potential interface design documents; provided GIS technical expertise and participated in collaborative design decisions.

(3) Held a series of planning meetings to
- Determine the most appropriate designs for MAGIS. In particular, designs for MAGIS-X were fine tuned by detailed discussion. Meetings with potential users of MAGIS-X guided priorities. The latter generated further interest in using MAGIS among Forest Service Region 1 planners.
- Define the envisioned final product characteristics to be attempted during the construction phase of the GIS interfaces.

Not only was the design of the MAGIS program interface fundamentally improved by an expansion incorporating two versions of MAGIS into one package: MAGIS-Express (MAGIS-X) and MAGIS-Professional (MAGIS-Pro) but, also, eight GIS wizards and interfaces were identified and ranked by priority. These included the three interfaces mentioned in the RJVA agreement. Two of the original RJVA interfaces were assigned to UM to construct, and one of the newly envisioned interfaces was assigned to the IMI cooperator. The RMRS, FSL-Missoula cooperator also redesigned a portion of the MAGIS Visual FoxPro forms to accommodate the new organization of MAGIS into two versions. UM programmers began the construction phase on the two assigned interfaces.

Tasks envisioned at the time were:

(1) Obtain updated functional hierarchy for MAGIS-X.

(2) Complete a strategy to produce version 1.0. Field test to assess acceptance, usability, applicability, ease of use, for a range of users.

(3) Database requirements for an heuristic solver for MAGIS-X are to be determined when such a solver is purchased or developed by IMI. (FSL responsibility)

(4) Determine which MAGIS-Pro capabilities are better accomplished with GIS functionality.

(5) Devise and implement a system to coordinate programming specifications, programming, testing, debugging, and implementation of MAGIS-Express. Do the same between UM and FSL for MAGIS-Pro. Implement the system to track progress and delegate new tasks as needed.

(6) Provide for MAGIS-Pro interaction with the SIMPPLE simulator (FSL responsibility).

(7) Provide a soundly organized, modular program structure.

(8) Refine final product characteristics' specifications in conjunction with results obtained during the solution implementation phase.

(9) Write, test, and debug code for the remaining interfaces.

Items of known interest which had yet to be addressed in the design phase were:

- User specification of forest corridor routes and security areas potentially selectable by the optimization process. Low priority, based on user feedback.

- User specification of Special Relations zones inclusions and exclusions prior to optimization. Low priority, based on user feedback.

The **second progress report** (February 5, 2003) described work guided by the task list presented at the end of the first progress report. A strategy document incorporated items from the task list as they pertained to MAGIS-X, and focused on meeting the requirements of clients having the most pressing need for a tactical planning tool. It called for updating working documents, completing design documents and programming specifications for priority interfaces, devising and implementing a system to coordinate programming specifications, programming, testing, debugging, and implementation of MAGIS-Express. Further, we incorporated or adopted methods that conformed to standard software engineering practices at each stage of the software cycle. Six software engineering steps were identified as follows:

- Software requirements analysis: Gathering requirements from the customers. Could be realized by establishing several versions of prototypes (Graphical User interfaces) and User Manual/Requirements Specification.
- Architecture design: Provide the top-level technical structure of the software. An Architecture document containing the overall description of the program organization should be created after the architecture design is finished.
- Detail design: Focus on all the specific parts of the system that will be shipped.
- Construction (Implementation or coding): Program writing.
- Testing: Quality Assurance activities.
- Delivery: Deliver the software to the end users.

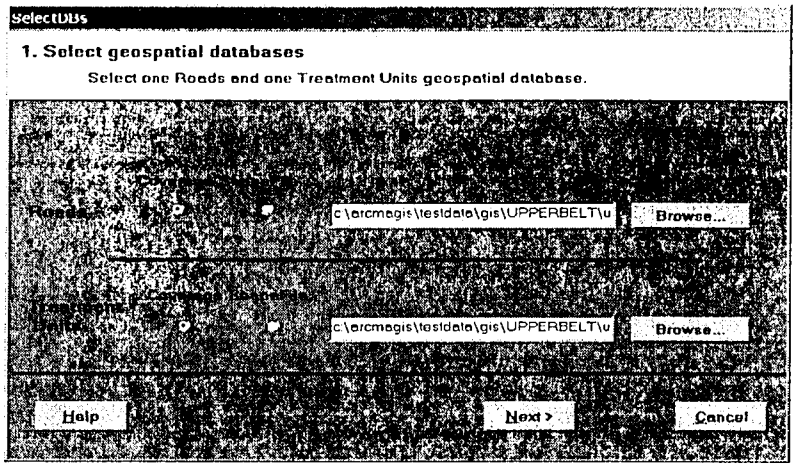
Software requirements analysis was nearly complete and the focus of team work tasks shifted away from planning and towards the construction, testing, and delivery stages. All working documents were stored in the FSL SourceSafe archives. They may be accessed/updated as needed. See Appendices A and B for examples of documents used by UM programmers during the construction phase.

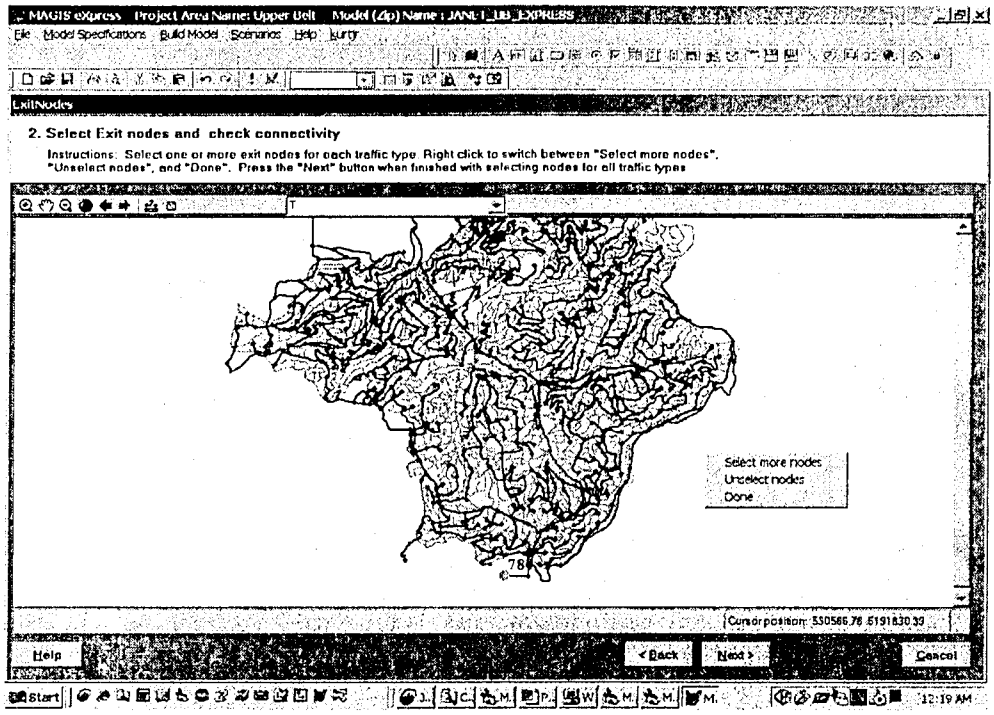
Continued meetings led to assignments by team consensus to GIS, VFP, and user documentation work groups. Levels of testing tasks were assigned to code and user documentation authors and work group leaders. An initial selection of field testers was

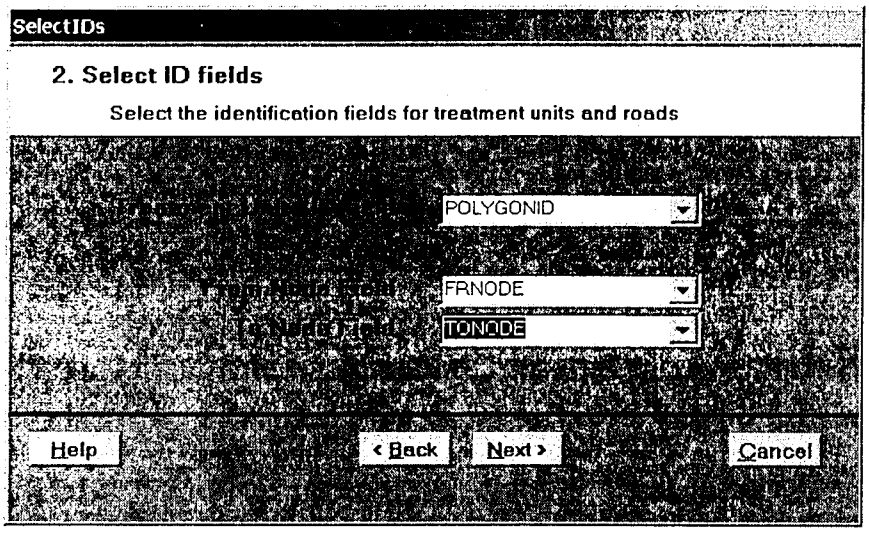
made. The exact contents of the first release of MAGIS-X were finalized in mid-November 2002. A testing plan for MAGIS-X was recommended to and approved by cooperators. A progress tracking document provided a quick view of all of the forms, activeX components, stand-alone programs, and testing steps required to complete MAGIS-X, version 1. The eight GIS wizards/interfaces were reduced to seven by combining the import wizards for roads and for treatment units into one wizard, the GIS Import Wizard.

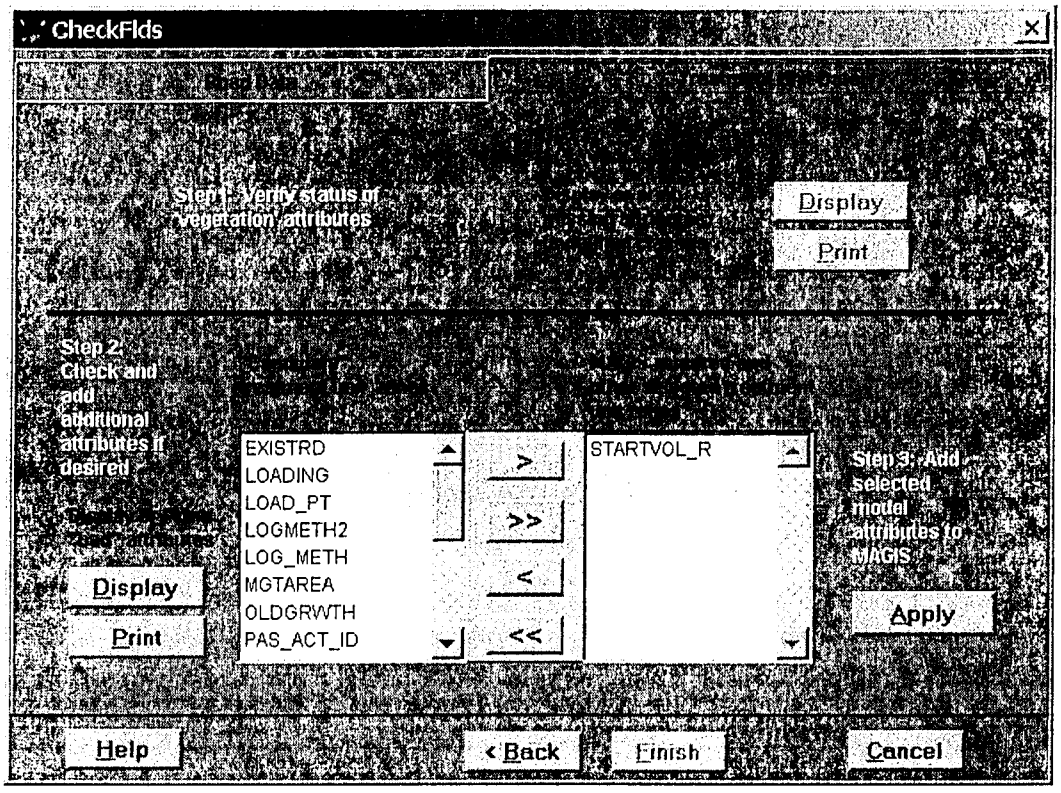
Development methods which were evaluated and reported in the first progress report have proven to be effective approaches. Considerable progress was made by UM programmers to develop coding techniques and write code for the assigned interfaces for MAGIS-X, version 1.1. This included GIS code and also techniques to incorporate the completed GIS components directly into Visual FoxPro forms. Completed ArcGIS VB-ArcObjects ActiveX components were integrated into three of the four GIS Import Wizard forms; additional, related Visual FoxPro code for form 4 of the wizard was written as well. Successful GIS coding led to the stage where specifications for these interfaces could be refined. Favorable reception by FSL personnel also led to requests for further functionality and finely tuned interface behavior and performance.

The four reduced screen capture runtime images below depict completed versions of the four forms, including one interactive map, for one MAGIS-X test model database. The functionality of the first three is described in wizardDescr.doc and ExitNodesDescr.doc. The fourth is based on a pre-existing ESRI ArcView version; adjustments were made according to verbal team instructions. The GIS activeX components included in forms 1-3 contain approximately 9100 total lines of VB6/ArcObject code.




ExitNodes
2. Select Exit nodes and check connectivity
Instructions: Select one or more exit nodes for each traffic type. Right click to switch between "Select more nodes", "Unselect nodes", and "Done". Press the "Next" button when finished with selecting nodes for all traffic types
Select more nodes
Unselect nodes
Done
Help
< Back
Next >
Cancel


SelectIDs
2. Select ID fields
Select the identification fields for treatment units and roads
POLYGONID
FRNODE
TONODE
Help
< Back
Next >
Cancel

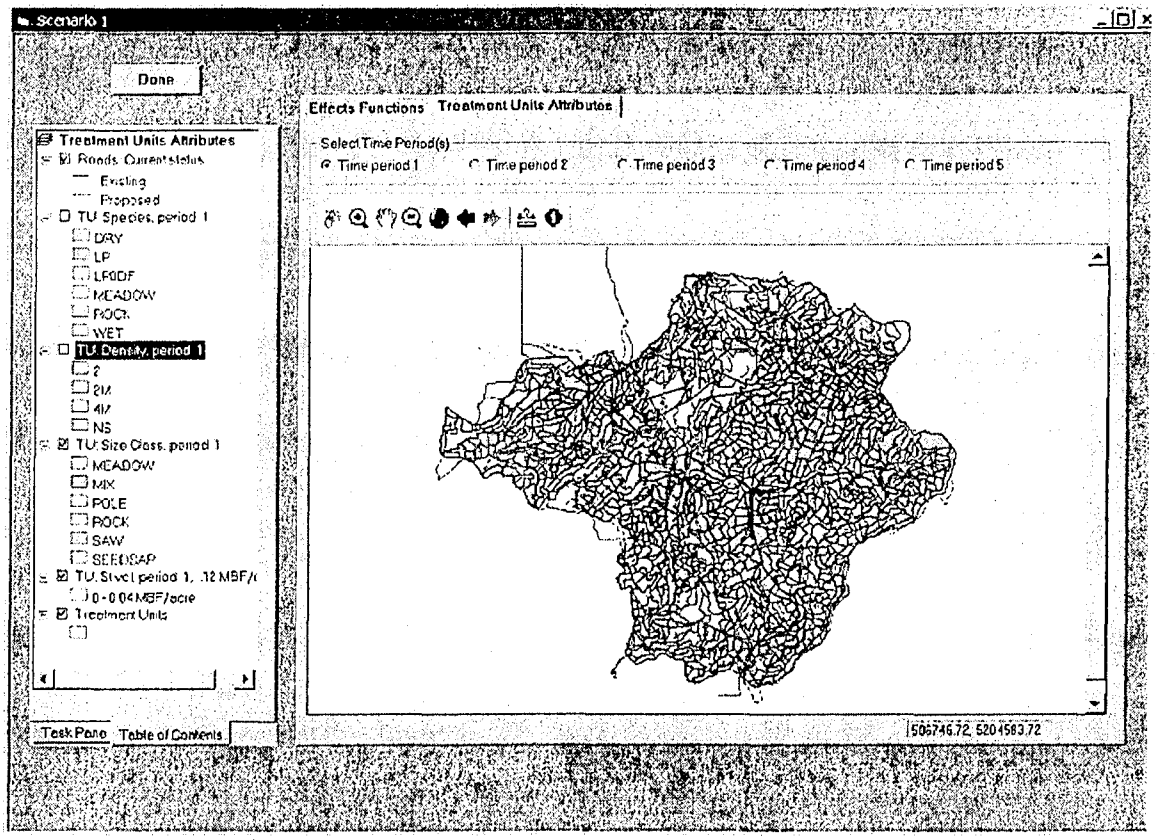


Work had begun on version 1.2 of MAGIS Express. The strategy was to include these interfaces:

Setup – Decision Variables	(coding by UM)
Display Solutions	(coding by UM)
Loading Nodes	(coding by IMI)

The Display Solutions interface, begun earlier, was being revised to include new features and characteristics specified by collaborators during design review meetings. This interface, coded in VB6/ArcObjects has a look and feel similar to that of ArcGIS ArcMap. Additionally, it provides for approximately fifteen custom map displays in one interface (providing a task pane and option buttons to navigate among them) and displays Scenario solutions attribute information in three status bars.

The runtime image below shows one of the fifteen maps being displayed by the Display Solutions interface, the treatment units attributes map, for one MAGIS-X test model database. This map is for planning period 1. The visible layers (toggled to on) in this image are road current status and vegetation size class at period 1 for the particular scenario solution being displayed. The capabilities of and programming instructions for this interface are described in the documents display_solutions_description.doc and display_solutions_functionality.doc respectively. The primary GIS activeX component (containing the map display and the task pane) coded for this interface and embedded in a VFP form contains approximately 8904 lines of VB6/ArcObjects code. The Table of Contents activeX control (map legend) was adapted from third party software by UM programmers and included in several GIS interfaces.



Technical support was being provided to the IMI programmer, who had coded a draft version of the loading nodes interface. Programmers meetings (UM and FSL) were being held regularly to track progress and coordinate testing and integration of GIS software components into MAGIS-X. Coding continued parallel to that of FSL VFP programmers.

The remaining tasks were to review/complete designs/programming specifications and to code and document the remaining GIS interfaces:

Setup – Decision Variables	(coding by UM)
Road options, costs interface	(coding by UM)
Traffic costs interface	(coding by UM)
Edit Resource Projects	(coding by UM)

Implicit in this were the tasks of writing VFP code to integrate the GIS interfaces into MAGIS and to continue with project management duties, tech support, and cooperative communications as needed.

Achievements: 2003 - present

Objectives, Goals, and Software Characteristics

Program development methods which were evaluated and presented in the first progress reports have continued to be an effective approach. With these, UM has produced GIS interfaces which present large amounts of highly complex information in a compact manner that provides easy interaction for MAGIS users. Some of the interface designs facilitate data entry, reducing tedium and improve accuracy. Design specifications have been shown to effectively guide program development in the construction and testing stages. The success of initial designs, coding approaches, design reviews, and demonstrations of work completed have led to requests for additional functionality in completed interfaces. Integration of completed work into the MAGIS-X framework has entailed VFP coding by the lead UM programmer.

Regarding the broader goals of FSL and IMI collaborators (mentioned in the first progress report) on the MAGIS development team, FSL MAGIS VFP programming efforts have continued in parallel with those associated with the development of multiple GIS interfaces. FSL has located a suitable programmer to provide a heuristic solver for MAGIS-Express and has worked with that collaborator to specify functionality requirements and to determine database requirements for the solver. FSL staff members have made progress in writing user documentation for the MAGIS-Express menu system. FSL staff have begun to prepare an overall design document specific to MAGIS-Pro (similar to that produced by UM for MAGIS-Express), and have made preliminary recommendations of adjustments to UM GIS wizards/interfaces for inclusion in the Pro version of the combined software package.

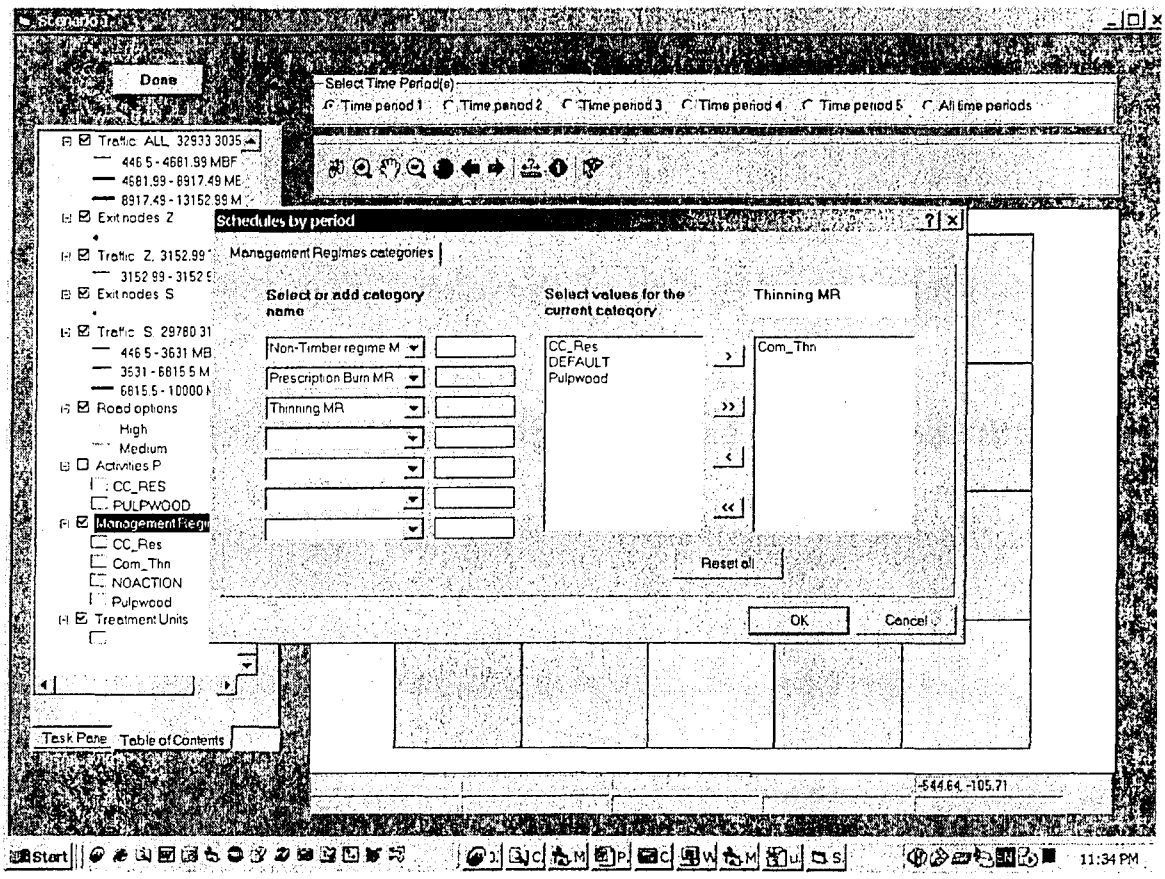
Further, as a result of increased interest in MAGIS, Region 1 planners have entered into an agreement with FSL to improve the WATSED sedimentation modeling software and to integrate the same into the MAGIS framework. FSL has also begun additional resource modeling projects, facilitated by overall and GIS improvements in MAGIS.

Methods

UM programmers have devised additional programming techniques within the context of the preferred approach of using ArcObjects and Microsoft components in the VB 6 development environment. Notably, (1) a method allowing users to classify the map symbology for management regimes or activities, (2) a filtered map selection tool, and (3) methods to display/edit the Microsoft DataGrid object simultaneously with interactive map selection and editing have been developed, tested, debugged, and incorporated into interfaces.

The first method (1) is used in the Display Solutions and Set Decision Variables interfaces. This adds approximately 2700 lines of code to the Table of Contents for Display Solutions and 1500 lines of additional code for Set Decision Variables. Method (2) is being used in Set Decision Variables, Road Options/Costs, Traffic Costs, and Build/Edit Resource Projects interfaces. Method (3) is being used in the same interfaces as method (2). The code for both of methods (2) and (3) is integrated into the primary activeX controls' procedures in the interfaces for which they are used.

The runtime image below shows (1) being used with the Display Solutions interface for management regimes for one MAGIS test model database. Category names, regimes assigned to each category, and fill symbols used for each category may be defined by the user.



Integrating GIS interfaces seamlessly into the MAGIS framework requires that data input to and/or output from these interfaces must be well coordinated with internal MAGIS tables. The entity-relationship diagrams that were designed by the development team and their related documentation provided guidelines for the content of the input/output tables. Further coordination with FSL programmers finalized the table definition details. FSL programmers have provided actual input tables for programming/unit testing purposes when requested.

We have continued to apply the Quality Assurance testing plan mentioned in an earlier report. There are five levels of testing:

(1) Unit testing by individual UM GIS programmers.
(2) Technical review by lead UM GIS programmer.
(3) Integration testing (GIS components in VFP forms, by lead UM GIS programmer).
(4) MAGIS integration testing (GIS-VFP form in MAGIS framework, by FSL programmers).
(5) System testing (running the entire software package with interfaces integrated).

The level (5) testing may be done by FSL MAGIS users, FSL system testers, or FSL clients. Any of these testers may suggest refinements or future software functionality enhancements. A system of documenting tester and user suggestions has been implemented. Integration testing may be guided in the future by detailed testing documents (if funded). We have requested that all MAGIS testing be done with at least two model databases prior to testing by FSL clients.

Accomplishments

Software requirements and programming specifications have been completed for all eight GIS wizards/interfaces.

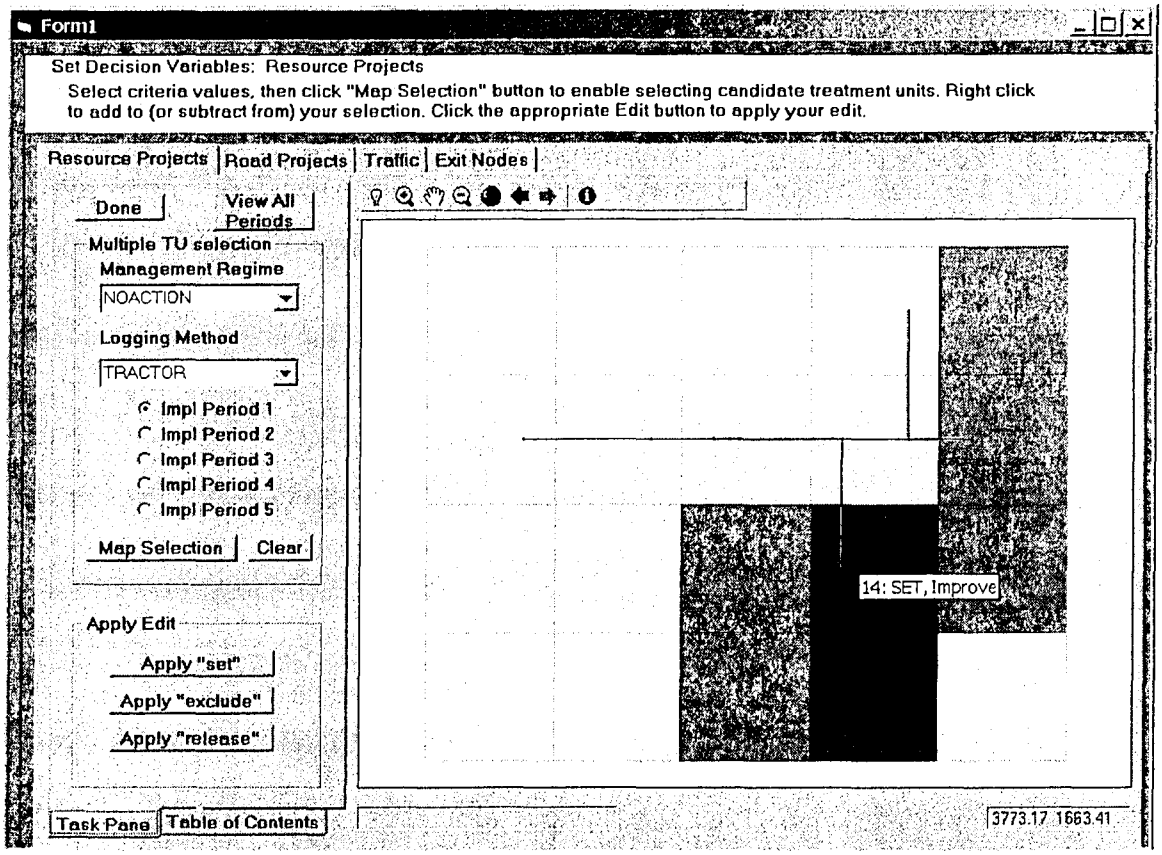
Development team meetings have been less frequent, once or twice per month to brief local PI's and discuss any issues as they arise. Cooperation with IMI has continued in the form of tech support for the loading nodes interface and coding in VFP to integrate the interface into the MAGIS-Express framework, and also to keep IMI programmers informed about local development news. A demo for FSL MAGIS staff led to suggested additional functionality and display enhancements in the loading nodes interface. FSL staff has made progress in writing user documentation for the MAGIS-X framework.

Work was completed according to priorities set by the development team. The order of construction of the seven wizards and interfaces (six of the seven were assigned to UM, loading nodes was assigned to IMI) and their completion status is as follows:

1. GIS Import Wizard (four forms): Has been integrated into MAGIS and has passed testing level (5) -- FSL users only. Program documentation includes comments in procedure headers. (See graphic above, in the section reviewing the second progress report.) The Pro version of the wizard has been set as the next programming priority.

2. Set Decision Variables: Has been integrated into MAGIS and has passed testing level (4). Level (5) testing has been done by FSL users, and additional enhancements have been requested. Program documentation includes comments in procedure headers, flow chart and UML diagrams describing program structure (see Appendix C) and flow of program control during operation of the interface.

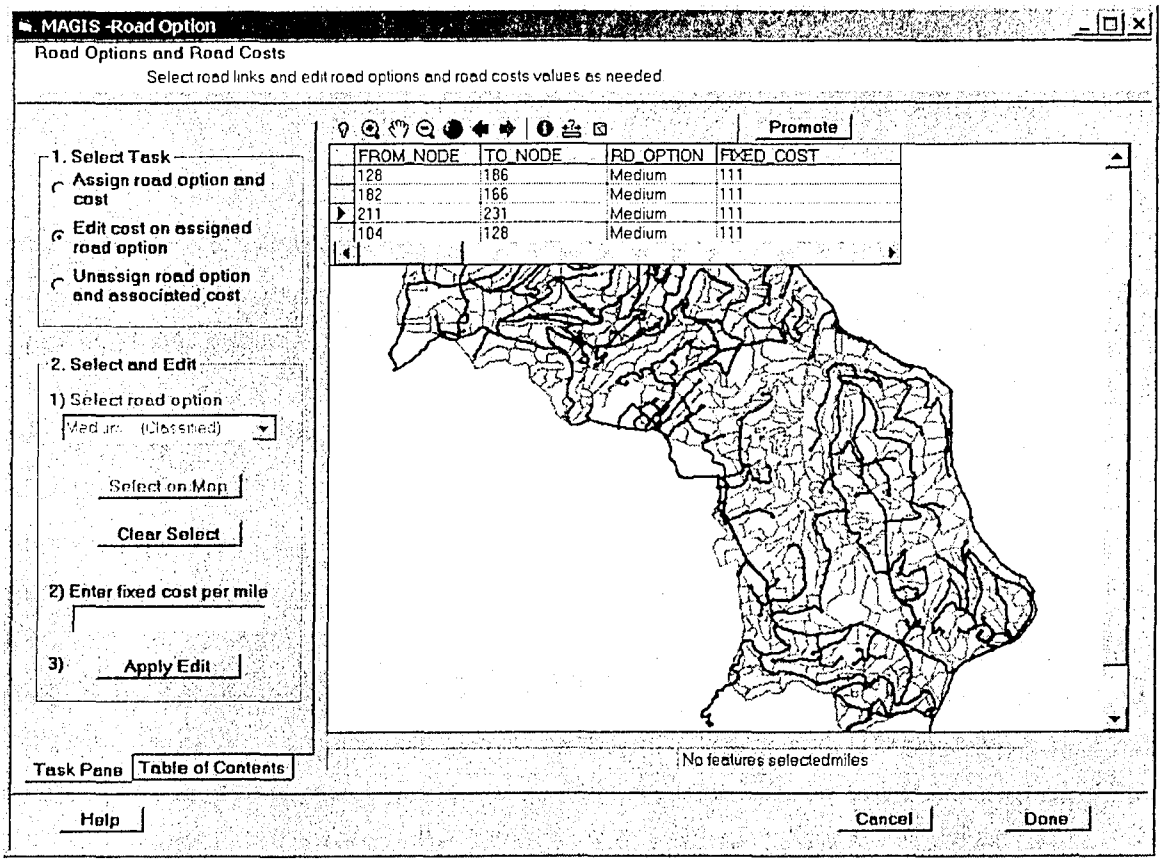
   The runtime image below shows an example of a map tip displaying a regime which has been set in period 2 for one MAGIS-X test model database. The bright green shows regimes which have been set in period 1. The user may also display all set or excluded regimes for the current period (period 1). The description and programming specifications for this interface are given in dec_varDescr.doc and "Functionality for Set Decision Variables.doc". This is the most complex GIS interface to date, containing approximately 22,000 lines of code for the primary activeX control. The main code module alone contains approximately 130 procedures.



3. Display Solutions: Has been integrated into MAGIS and has passed testing level (5) by one FSL MAGIS user; additional functionality has been requested. Program documentation includes comments in procedure headers. (See graphic in the section above which reviews the first progress report.)

4. Road Options and costs: VB controls, DataGrid programming and GIS map programming has been completed and has passed level 4 testing. Program documentation includes comments in procedure headers. Completed writing, testing, and debugging VFP code to integrate into the VFP framework. Legend designs are to be enhanced similar to requests for Display Solutions and Set Decision Variables.

   The runtime image below displays an example of the display table used in conjunction with a map display. The table is displayed after the user has selected a road option from the combo-box list and an interactive map selection is in progress. The documents "Road Options descr.doc" and "road_options_func.doc" served as guides during the construction and testing phases of this interface.



5. Traffic Costs: VB controls and DataGrid programming has been completed. The description and programming specifications documents for this interface are "traffic costs descr.doc" and "traffic costs func.doc". Program documentation includes comments in procedure headers. Completed writing, testing, and debugging VFP code to integrate into the VFP framework. Testing is at level 5.

6. Build/edit resource projects (assign management options to polygons): design documents and programming specifications completed. The description and programming specifications documents for this interface are "res projects descr.doc" and "resource projects func.doc".

7. Loading nodes interface: An initial version was demonstrated for FSL MAGIS developers and users. The description document for this interface is "create_connections_description.doc". Substantial additional enhancements were advised; coding for this is in progress by the IMI programmer. The lead UM GIS programmer has written code to integrate the interface into the MAGIS framework.

In addition, a draft version of the user documentation for each completed interface was written. Also continued to provide internal project management and tech support on an as-needed basis.

Appendix A

Two text documents were written for each interactive GIS interface: a description with overview and special features of the interface, and a functional description organized by objects in the interface. The two documents here are for the interface Set Decision Variables, and are representative of similar documents for other interfaces.

Description and Use of the Set Decision Variables GIS interface

Location in the MAGIS-X menu system

Pressing the 'Decision variables' command button on the Setup task pane of the Setup/Solve page in the Scenarios menu launches an interactive map interface.

Purpose of the interface

The interface is to allow the user to specify that certain values or limits be set for certain classes of decision variables for user-selected features for the current scenario. The interface has one tab for each of the following decision variable classes.

Resource projects: The user may select resource projects to be included in the solution, excluded from the solution, or released for selection by the solver. Resource projects are defined by a combination of treatment unit, management regime, logging method, and time period. Any treatment unit, for which no resource project has been set by the user, is to have one or more resource projects remaining available for selection by the solver. Values in the field 'Set' are edited as a result of user interaction with the interface.

Functional view for Resource Decision Variables

Edit status of decision variable
- Edit single record
  - Navigate to record
  - Edit Set field
- Edit multiple selected records
  - Select decision variables for editing
  - Choose Set/Exclude/Release
  - Apply edit

Road projects: The user may select road projects to be included in the solution, excluded from the solution, or released for selection by the solver. A road project is defined by a combination of road link, road option, and time period. Some road options may be applied to existing roads and some to proposed roads. Any road link, for which no road project has been set by the user, is to have one or more road projects remaining available for selection by the solver. Values in the field 'Set' are edited as a result of user interaction with the interface.

Functional view for Road Decision Variables

Edit status of decision variable
- Edit single record
  - Navigate to record
  - Edit Set field
- Edit multiple selected records
  - Select decision variables for editing (see below)
  - Choose Set/Exclude/Release
  - Apply edit

Traffic: The user may select whether a road link is to be closed to traffic or be allowed to have traffic for one or more traffic types, road options, and current road states (existing/proposed). Values in the 'ToTraffic' field are edited as a result of user interaction with the interface.

Functional view for Traffic Nodes Decision Variables

Edit status of decision variable
- Edit single record
  - Navigate to record
  - Edit ToTraffic field
- Edit multiple selected records
  - Select decision variables for editing
  - Enter ToTraffic value
  - Apply edit

Exit nodes: The user may set lower and upper limits for traffic volume for one or more exit nodes for one or more traffic types. Values in the fields 'LowerLimit' and 'UpperLimit' are edited as a result of user interaction with the interface.

Functional view for Exit Nodes Decision Variables

Edit status of decision variable
- Edit single record
  - Navigate to record
  - Edit LowerLimit, UpperLimit fields
- Edit multiple selected records
  - Select decision variables for editing
  - Enter LowerLimit, UpperLimit values
  - Apply edit

Validation rules and constraints

Resource projects: The 'Set' field values must be Null (release), 0 (exclude), or 1 (set). The sum of the Set field values for all records belonging to a single treatment unit must be <= 1. If the sum is less than 1, there must be at least one record having the value 'Null' in the Set field.
Road projects: Values in the field 'Set' for a road link must be Null (release), 0 (exclude), or 1 (set). The sum of the Set field values for all records belonging to a single road project must be <= 1. If the sum is less than 1, there must be at least one record having the value 'Null' in the Set field.

Traffic: Values in the field 'ToTraffic' must be 'Y' (close to traffic) or 'N' (allow traffic). There are no MAGIS restrictions on how many road links or for which time periods these values may be specified by the user.

Exit nodes: The value of 'LowerLimit' must be equal to or greater than 0.

Tasks to be performed programmatically as aids to the user

- Perform validation checks.
- Coordinate the map and table display for each selection method.
- Make graphic map layers available as aids to the user in making decisions. The user may toggle map layers on/off as needed.
- Provide a filtered map selection tool, incorporating attributes appropriate for each decision variable class and attribute values selected interactively by the user.
- Provide any background processing related to interactive map selection or table editing actions.
- Perform table edits for multiple-select option.

Cartographic display, map display controls, legend

- Include ESRI controls as follows
    - Map display pan and zoom control buttons.
    - Map identification and measurement tool buttons.
    - Clear Selection and Zoom to Selected tools.
- Include an ESRI Table of Contents legend including map layers appropriate for the tasks to be completed by the user. Layers and legend classes appropriate for each decision variable are given in the section Map display, in *Detailed Functionality for Set Decision Variables Screens.*

Placement and function of controls on the form

- See the form graphics in dec_var.vsd for type and placement of controls on the form tab pages. See *Detailed Functionality for Set Decision Variables Screens* for the capabilities of task panel controls.

- The task panes should be in the same location on each as the Table of Contents (TOC). The user toggles between them via the tabs located at the bottom of the pane/TOC.

- The interactive table is to have these characteristics:

    - Allow the user to sort the table by any field.

    - Allow the use to edit only the pertinent field for each decision variable class: 'Set' for resource projects and road projects, 'ToTraffic' for traffic, and 'LowerLimit' and 'UpperLimit' for exit nodes.

    - The table should not enable the user to add or delete records.

Flow of work in using the forms

Resource projects tab and Road projects tab

To edit the status of one or more decision variables

A. To edit a single record

1. Navigate to a record in the table

2. Edit the Set field

B. To edit multiple records

1. Select decision variable records for editing via the map selection tool.

2. Choose the Set, Exclude, or Release button to apply edits.

   If an error message appears on the Set command, the total value of Set field values for one or more road links represented by the selection set has exceeded 1. Release or exclude one or more projects before proceeding.

   If an error message appears on the Exclude command, there has been an attempt to exclude all projects for one or more features represented by the selection set. Release one or more projects for those features before proceeding.

3. Repeat steps 1 and 2 as needed.

Traffic closure tab

Editing the status of one or more road decision variables

A. To edit a single record

1. Navigate to a record in the table.
2. Edit the Set field.

B. To edit multiple selected records

1. Select decision variable records for editing via the selection tool (see below).
2. Choose Close to traffic or Allow traffic command button to apply edits.
3. Repeat as needed.

Exit nodes tab

Editing the status of one or more road decision variables

A. To edit a single record

1. Navigate to a record in the table.
2. Edit the LowerLimit and UpperLimit fields.

B. To edit multiple selected records

1. Select decision variable records for editing via the standard ESRI selection tool.
2. Edit the LowerLimit, UpperLimit text boxes and press the Apply button. If an error message appears, the lower limit is < 0; enter a number >= 0 and try again.
3. Repeat as needed.

Selecting decision variable records for editing multiple records (applies to resource projects, road projects, and traffic closure)

1. First select criteria (attribute values) from the map selection control group.
2. Select features on the map to create or modify a selection set of table records:

   a. To create a new selection set

      (1) Click on selection tool

      (2) Click on a single road feature, or

(3) Drag a bounding rectangle around several road features.

b. To Add records to the current selection set

(1) With the SHIFT key depressed, click on a single unselected road feature or

(2) With the SHIFT key depressed, drag a bounding rectangle around several unselected road features, or, with the Ctrl key depressed, click on the selection button of an unselected table record.

c. Remove records from the current selection set

(1) With the SHIFT key depressed, click on a single selected road feature,

(2) With the SHIFT key depressed, drag a bounding rectangle around several previously selected road features, or

(3) With the Ctrl key depressed, Click on selection button of a selected table record.

Additional notes to the programmer

1. Filtered map selection tool. The 'New' selection option is set programmatically and retained for adding features to and removing features from the selection set.

2. No features are highlighted on the map until the user interacts directly with the map or table, that is, selecting criteria values has no effect on the display.

3. When the user selects features on the map, only those features and records meeting the criteria in the Map Selection Tool Group are highlighted.

4. For multiple-record selection, when features on the map are selected, records in the table that meet the criteria in the Map Selection Tool Group are also selected and highlighted. When a single record is selected in the table, the corresponding feature is highlighted on the map.

5. During selection, the total number of acres, miles, miles, and nodes, respectively, currently selected are to be displayed in the status bar.

6. Apply buttons are enabled only if the associated selection set is not empty.

7. Whenever an edit is made, update all tables and the view shown to the user.

8. Pressing any apply button activates the associated validation check. If there is an error, print a message to the screen. See the sections on Validation Rules and Flow of Work for details.

9. No context menu is required.

Detailed Functionality for Set Decision Variables Screens

General Purpose of Screens

These screens allow the user to control which decision variables are in a solution. Users can Set (force into solution), Exclude (force out of solution) or Release (allow solver to choose) model decision variables. The three classes of decision variables, Road Projects, Resource projects and Traffic Flow, each have their own screen, present on a different Tab of this form. The key attributes for a decision variable are visible in the table control. The user performs the action of Set, Exclude or Release by editing the Set field of the decision variable record. Edits can be done to single records in the table or to multiple records after they have been "selected". A filtered map selection tool helps the user locate and select records to be edited.

Control View

I. Road Variables

On tab select: make only road links selectable; force the base road layer to be visible always and not moveable.

Multi-Record Edit Group
- Set/Exclude/Release command buttons
  - Disabled when no records are selected
  - Enabled when any records are selected.
  - Validation rules / error conditions
    - Set operation
      1. More than one decision variable is set for a road link. Cancel that portion of the transaction (valid edits to other links in the selected set will be executed). Give error message saying which variables were not set, inform they must release variables first.
    - Exclude operation
      1. All decision variables for a link have been excluded. Edit no records for that link. Give error message.
  - Actions upon successful validation
    - Apply edit to Set field of table for all selected records: Set = 1, Release = ' ' (null), Exclude = 0
    - Update Layers in map display.

Map Selection Tool Group
- The controls in this group affect the behavior of the map selection tool.
- Status combo box.
  - Contains "Existing" "Proposed", "Both" selections. No action on change.
- Road option combo box.

Contains all defined Road Options (SELECT rd_option FROM _7) plus "All". No action on change.
- Implementation period check boxes.
  - Normal functionality, no action on select.
- Map selection tool button.

On select: change appearance to depressed; change currently selected tool to unselected; check for at least one implementation period checkbox selected. If not, give error message.

Map selection tool functionality.

See accompanying document Interactive_Selection_functionality.doc

II. Resource Project Variables

On tab select: make only treatment units selectable;

Multi-Record Edit Group

Set/Exclude/Release command buttons

Same as I. Except:

Validation rules / error conditions

Set operation

More than one decision variable is set for a treatment unit. Cancel that portion of the transaction (valid edits to other units in the selected set will be executed). Give error message saying which variables were not set, inform they must release variables first.

Exclude operation

All decision variables for a treatment unit have been excluded. Edit no records for that unit. Give error message.

Actions upon successful validation

Apply edit to Set field of table for all selected records: Set = 1, Release = ' ' (null), Exclude = 0

Update Layers in map display.

Map Selection Tool Group

The controls in this group affect the behavior of the map selection tool.

Management regime combo box.

Contains List of management regimes (SELECT name FROM _43b) plus "All".

No action on change.

Logging method combo box.

Contains all defined Logging methods (SELECT log_mth_n FROM _30) plus "All".

No action on change.

Implementation period check boxes.

Normal functionality, no action on select.

Map selection tool button.

Same as I.

Map selection tool functionality.

See accompanying document Interactive_Selection_functionality.doc

III. Traffic flow Variables

On tab select: make only road links selectable;

Multi-Record Edit Group

Close/Don't Close command buttons

Same as I. Except:

Validation rules / error conditions

Actions upon successful validation

Apply edit to Is_Closed field of table for all selected records: Closed = Y, Not closed = N

Update Layers in map display.

Map Selection Tool Group

The controls in this group affect the behavior of the map selection tool.

Traffic type combo box.

Contains traf_type values from _6.dbf.

Status combo box.

Contains "Existing" "Proposed", "Both" selections. No action on change.

Implementation period check boxes.

Normal functionality, no action on select.

Map selection tool button.

Same as I.

Map selection tool functionality.

See accompanying document Interactive_Selection_functionality.doc

Map Display

Ordering of layers: Road layers first, base road layer (existing – solid gray; proposed – dashed gray) is last of road layers, polygon layers next, base polygon layer (just the outline) is last of polygon layers. Order of layers cannot be changed by user. User can control which layers are visible.

User controls what layer set is visible by selecting one of 6 radio buttons: Period 1, Period 2 .... All Periods. On select of one of these radio buttons the layers are reconstructed accordingly.

Layers present in Traffic Flow Tab

Single period

Set traffic flow – resource project that has been set creates traffic period x

Classes – only one class

Closure to traffic - closed to traffic in period x (only one class) SELECT Road_link FROM TRAFFIC_VAR WHERE ToTraffic = 'Y' AND Period = *X*

All period

Set Road options - any road option has been set

Classes – period of implementation. SELECT Road_link, Period FROM ROAD_VAR WHERE Set = 1 GROUP BY Period

Closure to traffic – closed to traffic

Classes – period of closure. SELECT Road_link, Period FROM TRAFFIC_VAR WHERE ToTraffic = 'Y' GROUP BY Period

Layers present for Road option setting Tab

Single Period

Set traffic flow – resource project that has been **set** creates traffic or has an activity (requiring access) in period x

Classes – creates traffic; has any activity and produces no traffic

Closure to traffic – link closed to traffic in period x (only one class)
SELECT Road_link FROM TRAFFIC_VAR WHERE ToTraffic = 'Y' AND Period = *X*

Set or Exclude– link has a road option(s) set or excluded in period x
Classes – rd_option classes : SELECT Rd_Option, Rd_Link FROM ROAD_VAR WHERE Set = 1 AND Period = *X* GROUP BY Rd_Option;
plus additional class "exclude" : SELECT Rd_Link FROM ROAD_VAR WHERE Rd_Link NOT IN (SELECT Rd_Link FROM ROAD_VAR WHERE Set = 1 AND Period = *X*) AND Set = 0

All Period
Set – Show links with any road option "Set" or "Excluded"
Classes – period classes : SELECT Period, Rd_Link FROM ROAD_VAR WHERE Set = 1 GROUP BY Period;
Plus additional class "Excluded" : some road option excluded in any period. SELECT Rd_Link FROM ROAD_VAR WHERE Rd_Link NOT IN (SELECT Rd_Link FROM ROAD_VAR WHERE Set = 1) AND Set = 0

Closure – show links with traffic variables closed beginning this period
Classes – earliest period of closure is period 1; earliest period of closure is period 2...
SELECT Rd_Link, Min_Per FROM (SELECT Rd_Link, Min(Period) AS Min_Per WHERE ToTraffic = 'Y' GROUP BY Rd_Link) GROUP BY Min_Per

Layers present for Resource projects Tab:

Single Period
Set traffic flow – same as in Road Option Tab

Closure to traffic – same as in Road Option Tab

Set or Exclude– unit has a resource project set or excluded in period x
Classes – mgmt regime classes : SELECT Mgmt_Regime, Cut_un_id FROM RESOURCE_VAR
WHERE Set = 1 AND Period = *X* GROUP BY Mgmt_Regime;

plus additional class "exclude": SELECT Cut_un_id FROM RESOURCE_VAR
WHERE Set = 0
AND Cut_un_id NOT IN (SELECT Cut_un_id FROM RESOURCE_VAR WHERE Set = 1 AND Period = *X*)

Roads Set – road options with period of imp. <= period x
Classes – Road options :
SELECT Rd_Option, Rd_Link
FROM ROAD_VAR
WHERE Set = 1 AND Period <= *X* GROUP BY Rd_Option;

Polygon-to-Loading node connections
Classes – connection logging methods

Polygon-to-Loading node connections only for units that are Set
Classes – connection logging methods

All Period
Set – Show units with any resource project "Set" or "Excluded"
Classes – period classes : SELECT Implement, Cut_un_id FROM RESOURCE_VAR WHERE Set = 1 GROUP BY Implement;
Plus additional class "Excluded" : some resource project excluded in any period.
SELECT Cut_un_id
FROM RESOURCE_VAR
WHERE Set = 0 AND Cut_un_id NOT IN (SELECT Cut_un_id FROM RESOURCE_VAR WHERE Set = 1)

Polygon-to-Loading node connections
Classes – connection logging methods
Polygon-to-Loading node connections **only** for units that are Set
Classes – connection logging methods

Table Display

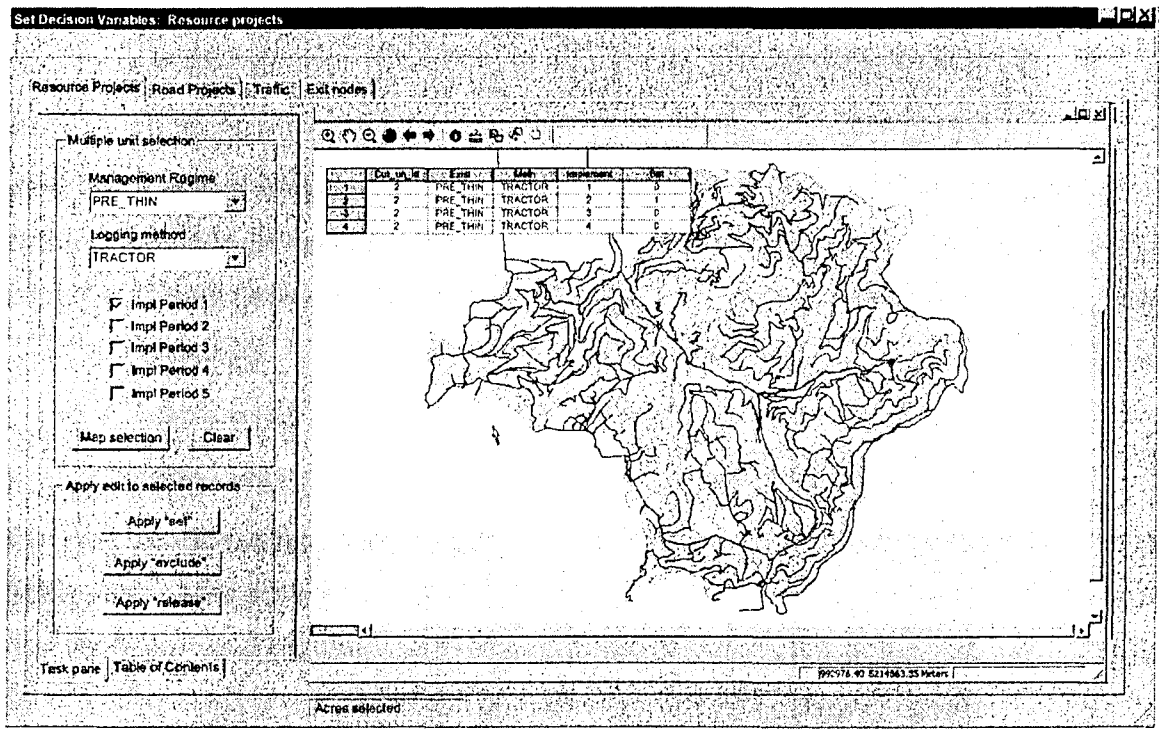
No delete, no Append,

Appendix B

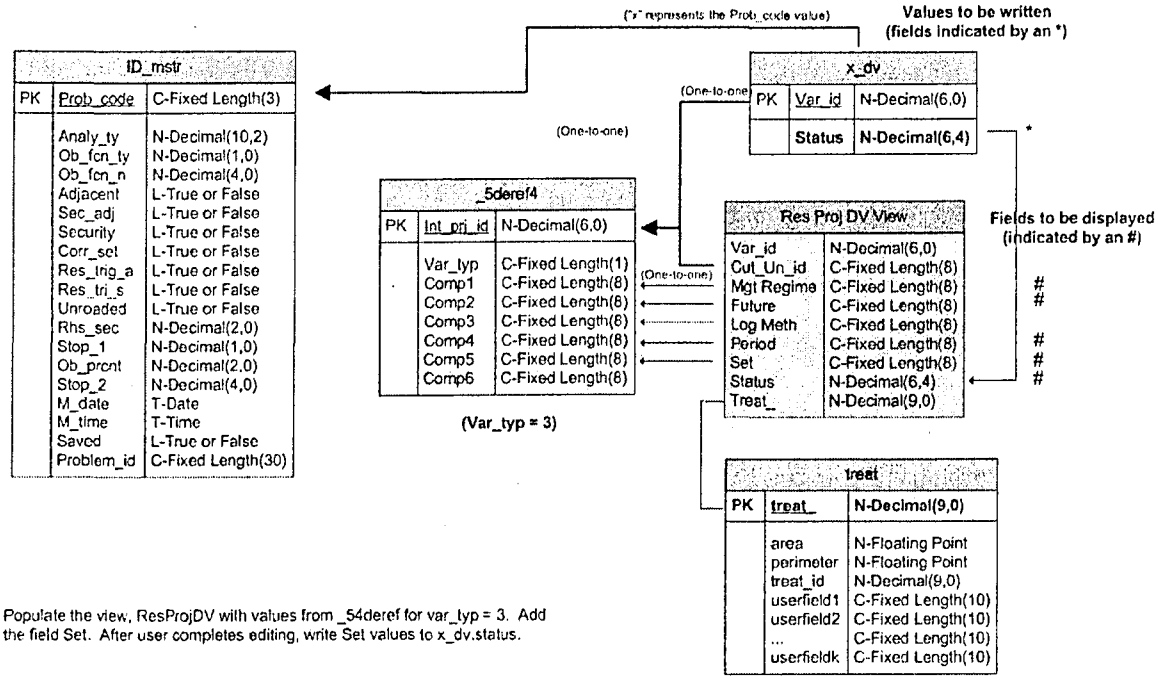
Construction of each interface was also guided by a (1) a design graphic depicting the layout of objects on the interface and (2) an entity-relationship diagram of the tables required as input for the interface. These were proposed and prepared by UM, and finalized based on MAGIS development team decisions. For the interface Set Decision Variables, there are four graphic design pages and five ERD pages. One of each (for Resource Projects decision variables) is shown here.

Setup/Solve — Set decision variables

Form design, Resource Projects



Set Decision Variables, Resource Projects



Populate the view, ResProjDV with values from _54deref for var_typ = 3. Add the field Set. After user completes editing, write Set values to x_dv.status.

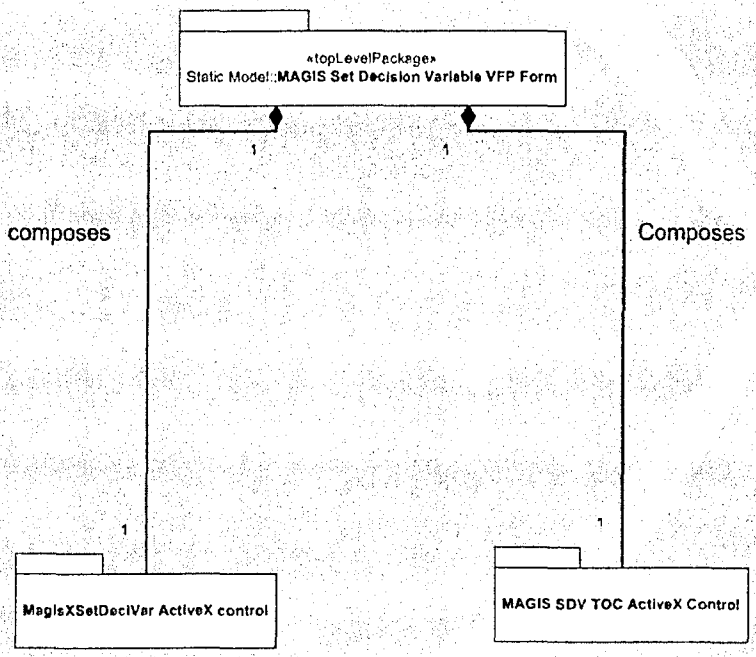
Appendix C

One goal of the software development project was to document program structure for later reference. Diagrams adhere to the standards for Unified Modeling Language (UML), drawn in Microsoft Visio. When viewed from within Visio, one may click hyperlinks to navigate from one page to another or zoom in to display greater detail. Four of fourteen graphics depicting the program structure for SDV are given here as example; those shown below are small enough for the printed page.

As an additional bonus, diagrams (for Resource Projects decision variables) depicting the flow of work by users are included as well.

Architecture of MAGIS Set decision Variables Application

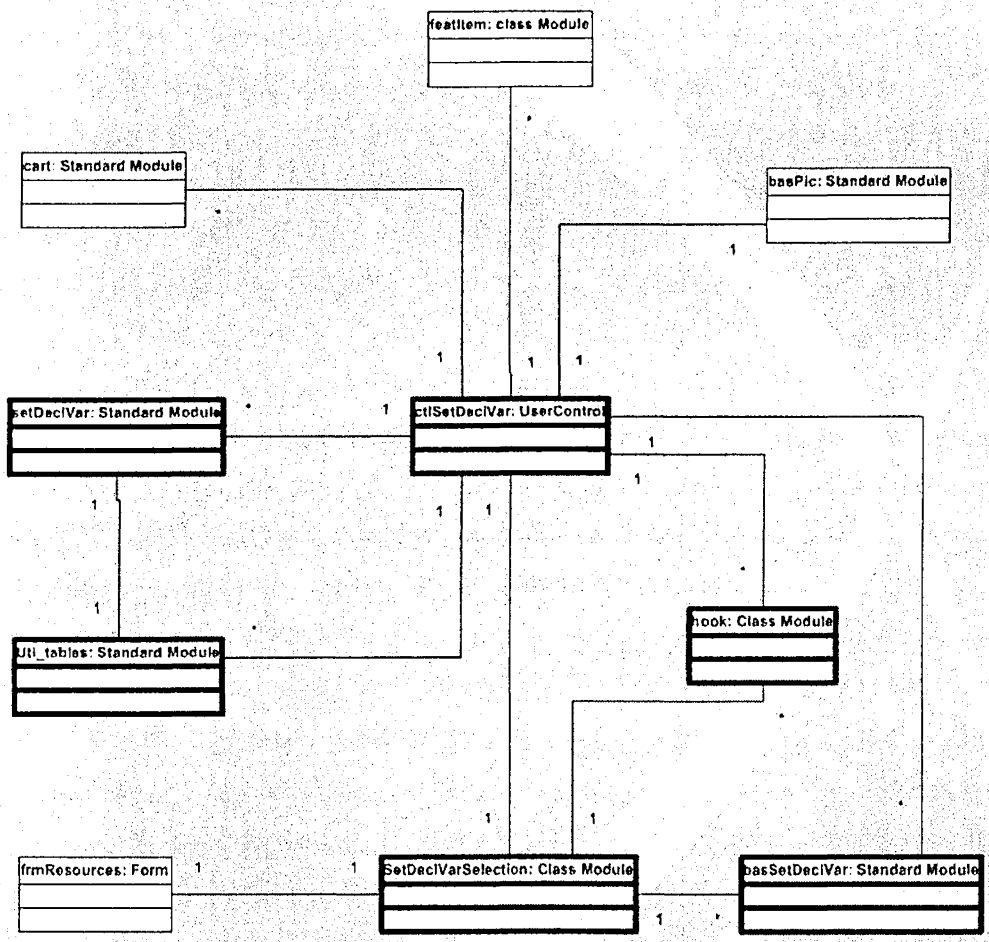
(Right Click each shape and click Hyperlink icon to browse the detail structure of each entity)



General Class Static Structure Diagram For MAGIS SDV ActiveX control

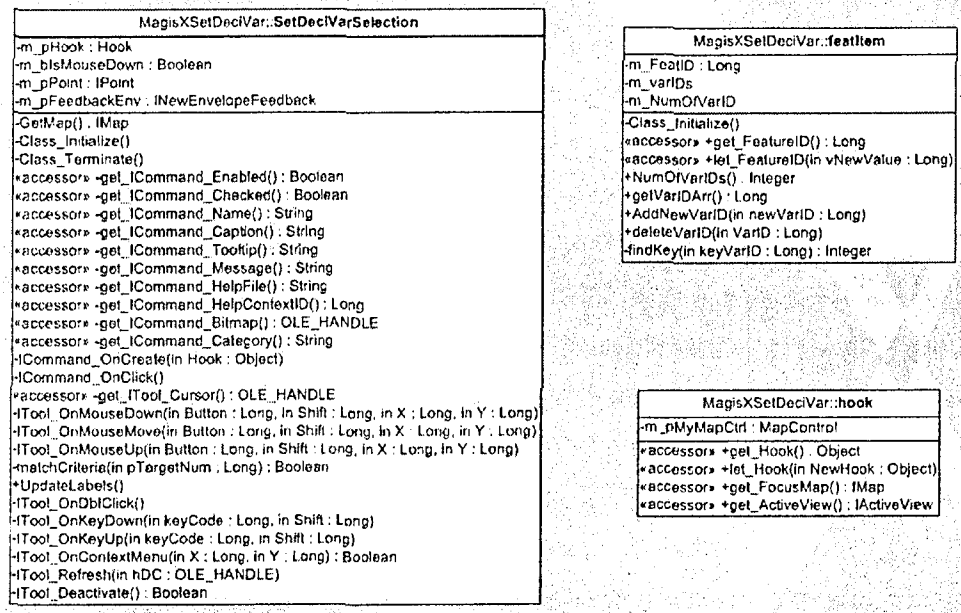
(All relationships in this diagram are "association" relationship)

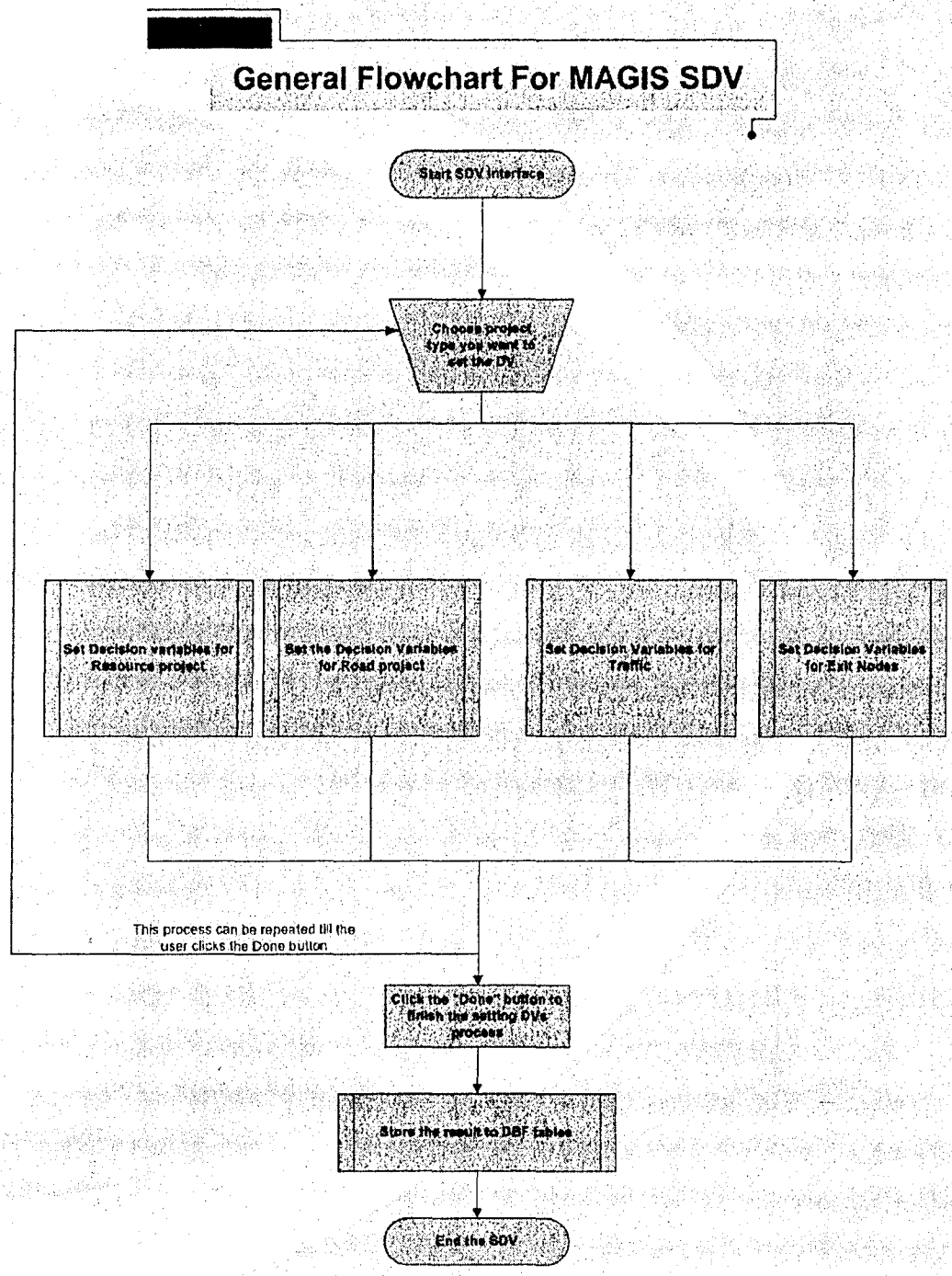
Right Click each shape and click Hyperlink icon to browse the detail structure of each entity



Back to General Structure

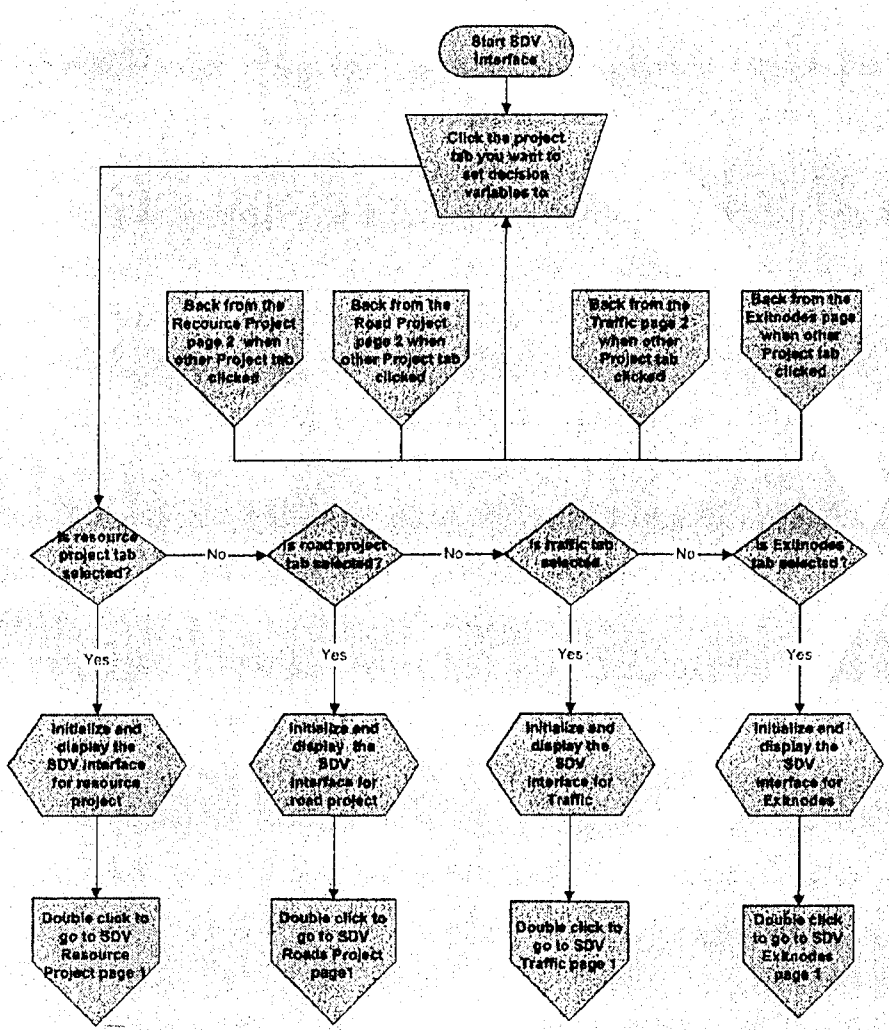
Detail Structure of SDV - Class Modules
(SetDeciVarSelection, featItem and hook)


MagisXSetDeciVar::SetDeciVarSelection
-m_pHook : Hook
-m_blsMouseDown : Boolean
-m_pPoint : IPoint
-m_pFeedbackEnv : INewEnvelopeFeedback
-GetMap() : IMap
-Class_Initialize()
-Class_Terminate()
«accessor» -get_ICommand_Enabled() : Boolean
«accessor» -get_ICommand_Checked() : Boolean
«accessor» -get_ICommand_Name() : String
«accessor» -get_ICommand_Caption() : String
«accessor» -get_ICommand_Tooltip() : String
«accessor» -get_ICommand_Message() : String
«accessor» -get_ICommand_HelpFile() : String
«accessor» -get_ICommand_HelpContextID() : Long
«accessor» -get_ICommand_Bitmap() : OLE_HANDLE
«accessor» -get_ICommand_Category() : String
-ICommand_OnCreate(in Hook : Object)
-ICommand_OnClick()
«accessor» -get_ITool_Cursor() : OLE_HANDLE
-ITool_OnMouseDown(in Button : Long, in Shift : Long, in X : Long, in Y : Long)
-ITool_OnMouseMove(in Button : Long, in Shift : Long, in X : Long, in Y : Long)
-ITool_OnMouseUp(in Button : Long, in Shift : Long, in X : Long, in Y : Long)
-matchCriteria(in pTargetNum : Long) : Boolean
+UpdateLabels()
-ITool_OnDblClick()
-ITool_OnKeyDown(in keyCode : Long, in Shift : Long)
-ITool_OnKeyUp(in keyCode : Long, in Shift : Long)
-ITool_OnContextMenu(in X : Long, in Y : Long) : Boolean
-ITool_Refresh(in hDC : OLE_HANDLE)
-ITool_Deactivate() : Boolean
MagisXSetDeciVar::featItem
-m_FeatID : Long
-m_varIDs
-m_NumOfVarID
-Class_Initialize()
«accessor» +get_FeatureID() : Long
«accessor» +let_FeatureID(in vNewValue : Long)
+NumOfVarIDs() : Integer
+getVarIDArr() : Long
+AddNewVarID(in newVarID : Long)
+deleteVarID(in VarID : Long)
-findKey(in keyVarID : Long) : Integer
MagisXSetDeciVar::hook
-m_pMyMapCtrl : MapControl
«accessor» +get_Hook() : Object
«accessor» +let_Hook(in NewHook : Object)
«accessor» +get_FocusMap() : IMap
«accessor» +get_ActiveView() : IActiveView

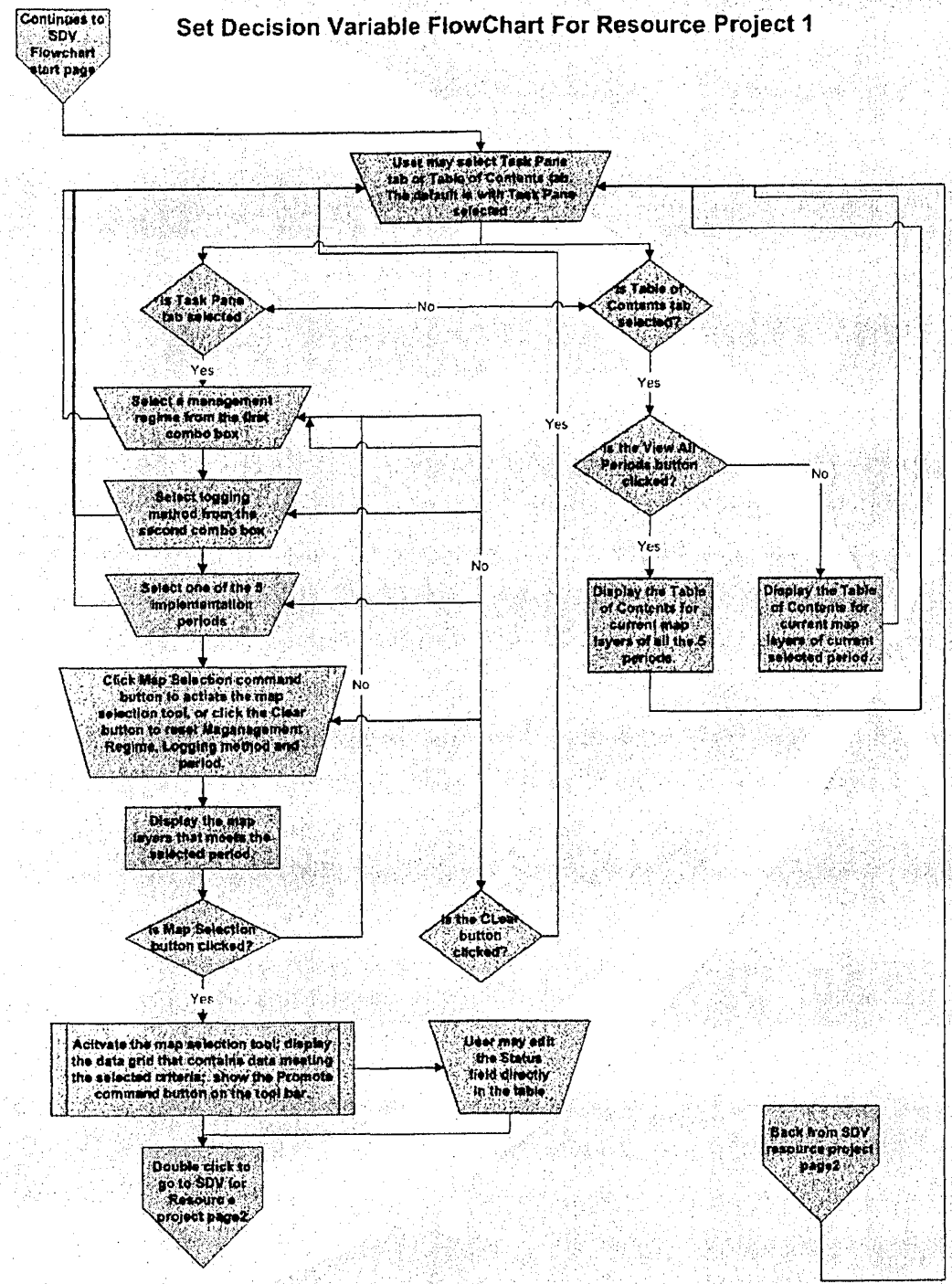

General Flowchart For MAGIS SDV
Start SDV interface
Choose project type you want to set the DV
Set Decision variables for Resource project
Set the Decision Variables for Road project
Set Decision Variables for Traffic
Set Decision Variables for Exit Nodes
This process can be repeated till the user clicks the Done button
Click the "Done" button to finish the setting DVs process
Store the result to DBF tables
End the SDV

Double click to go to the Flowchart end page

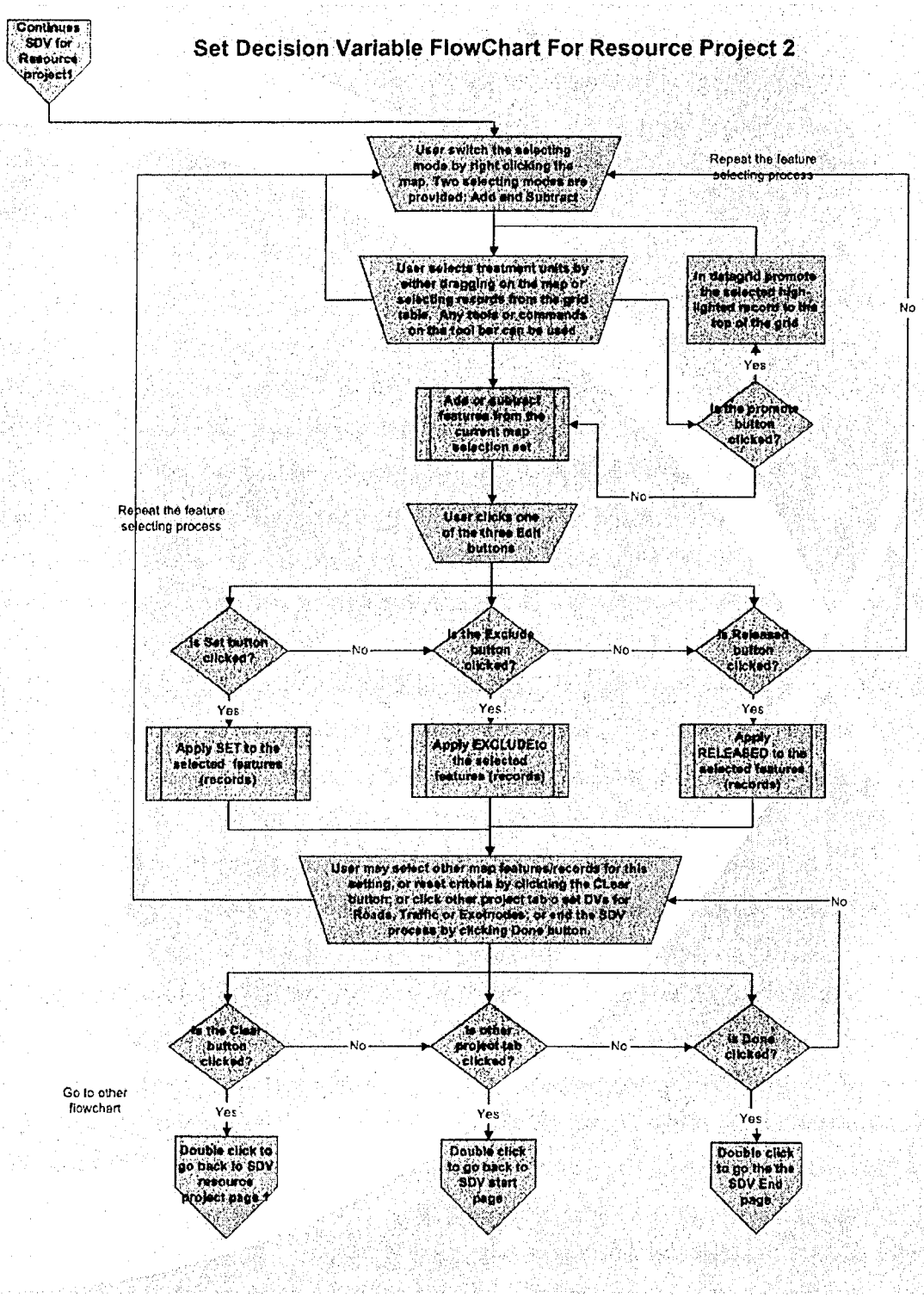
Flowchart for MAGIS SDV


Start SDV Interface
Click the project tab you want to set decision variables to
Back from the Recource Project page 2 when other Project tab clicked
Back from the Road Project page 2 when other Project tab clicked
Back from the Traffic page 2 when other Project tab clicked
Back from the Exinodes page when other Project tab clicked
Is resource project tab selected?
No
Is road project tab selected?
No
Is traffic tab selected
No
Is Exinodes tab selected ?
Yes
Yes
Yes
Yes
Initialize and display the SDV interface for resource project
Initialize and display the SDV interface for road project
Initialize and display the SDV interface for Traffic
Initialize and display the SDV interface for Exinodes
Double click to go to SDV Resource Project page 1
Double click to go to SDV Roads Project page1
Double click to go to SDV Traffic page 1
Double click to go to SDV Exinodes page 1

Set Decision Variable FlowChart For Resource Project 1


Continues to SDV Flowchart start page
User may select Task Pane tab or Table of Contents tab. The default is with Task Pane selected
Is Task Pane tab selected
No
Is Table of Contents tab selected?
Yes
Yes
Select a management regime from the first combo box
Select logging method from the second combo box
Select one of the 3 implementation periods
Click Map Selection command button to actiate the map selection tool, or click the Clear button to reset Maganagement Regime, Logging method and period.
No
Yes
Is the View All Periods button clicked?
No
Yes
Display the Table of Contents for current map layers of all the 5 periods.
Display the Table of Contents for current map layers of current selected period.
No
Display the map layers that meets the selected period.
Is Map Selection button clicked?
Is the CLear button clicked?
Yes
Activate the map selection tool; display the data grid that contains data meeting the selected criteria; show the Promote command button on the tool bar.
User may edit the Status field directly in the table
Double click to go to SDV for Resource project page2
Back from SDV resource project page2

Set Decision Variable FlowChart For Resource Project 2


Continues SDV for Resource project1
User switch the selecting mode by right clicking the map. Two selecting modes are provided: Add and Subtract
Repeat the feature selecting process
User selects treatment units by either dragging on the map or selecting records from the grid table. Any tools or commands on the tool bar can be used
In datagrid promote the selected highlighted record to the top of the grid
No
Yes
Add or subtract features from the current map selection set
Is the promote button clicked?
No
Repeat the feature selecting process
User clicks one of the three Edit buttons
Is Set button clicked?
No
Is the Exclude button clicked?
No
Is Released button clicked?
Yes
Yes
Yes
Apply SET to the selected features (records)
Apply EXCLUDE to the selected features (records)
Apply RELEASED to the selected features (records)
User may select other map features/records for this setting, or reset criteria by clicking the Clear button, or click other project tab to set DVs for Roads, Traffic or Exclmodes, or end the SDV process by clicking Done button.
No
Is the Clear button clicked?
No
Is other project tab clicked?
No
Is Done clicked?
Go to other flowchart
Yes
Yes
Yes
Double click to go back to SDV resource project page 1
Double click to go back to SDV start page
Double click to go the the SDV End page